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is more than equivocal and that the vitiation is of reasoning not of inheritance.

So far as I know, only one other investigator besides Russo has laid claim to having modified the ordinary course of Mendelian inheritance by external conditions. Such a claim, if I rightly understood him, was made by Professor W. L. Tower, in a paper read at the last annual meeting of the American Society of Naturalists, in the case of beetles of the genus *Leptinotarsa*. Detailed information regarding the cases in question will be awaited with much interest. It is to be hoped that this will prove more complete and satisfactory than Russo's.

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HARVARD UNIVERSITY,
June 11, 1910.

THE BUBONIC PLAGUE

BUBONIC plague is primarily an animal disease. Its original victim is said to have been a species of rodents found in the mountains of Mongolia. Several Russian scientists have sought to establish this hypothesis, according to which the *Arctomys bobac*, a Mongolian marmot, is the primitive animal host. In it the disease is permanently prevalent, and from it both man and the rat are infected periodically. According to the view of these writers the final eradication of the plague from our globe would be accomplished by the extermination of this rodent. That this view is over-optimistic may be inferred from the probable existence of other ancient centers from which plague epidemics have originated, and in which, consequently, permanently infected animals are at home, and also from the recent origin of such an established center of animal infection on our own continent.

In the introduction to an article on Plague Eradication Measures (Squirrel Campaign) in California, Rucker¹ comments on the epizootic which for four years has been spreading among the ground squirrels of Contra Costa County, and which more recently has been reported from other districts also. The animal infected is *Citellus beecheyi*, which is reported by ranchers to have died by the thousands in 1904-5-6. In appearance and habits, it resembles closely the Thibetan marmot referred to above. Not until there came cases of human plague due to plague-infected squirrels was the disease of the latter subject

¹ *Journal Amer. Med. Assn.*, Vol. 53, p. 1995.

to careful scrutiny. Wherry² first showed in a conclusive manner that ground squirrels, obtained from two widely separated sections of California, were infected with the bacillus of bubonic plague. There remained to be ascertained the extent of the infection and appropriate methods for the extermination of the infected animals and the eradication of the disease, which had gained apparently a permanent foothold on the state of California. The records of these investigations form one of the most interesting and important chapters of medical zoology yet written.

The splendid work which has been done by the Public Health and Marine Hospital Service on the Pacific coast in connection with the problem of stamping out bubonic plague, has included investigations on the rats and also on native rodents, which have established important points in the relations of these animals to the spread of that disease. While no cases of human plague have been reported for many months, yet plague-infected rodents have been killed at one point or another as recently as February. The disease is not common, since about 2,000 squirrels from one county were examined before an infected individual was found. Nevertheless, one can not doubt its continuance among the wild rodents, or question the advisability of prosecuting the campaign for the total eradication of the infected animals. The service has published³ complete statistics of work to date and a map showing the area studied and the prevalence of plague among ground squirrels.

The rodents in which plague infection has been demonstrated include both the introduced species, *Mus rattus*, the black rat, and *Mus norvegicus*, the brown rat, and also the native species, *Citellus beecheyi*, the California ground squirrel, and *Neotoma fuscipes*, the brush rat. The work of McCoy⁴ corroborated fully the findings of Wherry, and left no doubt that the disease among ground squirrels is due to the same organism that causes bubonic plague among rats and men. The experimental evidence which the latter reports in a conservative and critical manner includes several typical cases of plague in human beings where the diagnosis has been verified by bacteriological methods, and where the cases "have been traced to squirrel infection as clearly as one can trace such things." While McCoy states that in his

² *Journal of Infectious Diseases*, Vol. 5, p. 485.

³ "Public Health Reports," Vol. 25, p. 585.

⁴ "Public Health Reports," Vol. 25, pp. 27-33.

opinion the number of human beings infected directly by squirrels will never constitute a large element in the infected region, yet, on the other hand, one can not deny the patent facts that the infection of native rodents provides a retreat in which the disease is relatively safe from elimination and also a source from which it may be at any time transmitted anew to the human species. The transmission from rat to man through the intermediation of the fleas is easily conceived. The intimate association of the rat with human dwellings and with places constantly visited by man makes the transfer of the infected fleas an easy matter. The transmission of the disease in similar fashion among the animals in a squirrel colony is equally readily understood, though the booby owl, which regularly occupies the same burrows with the ground squirrel, may play the important part in the dissemination of the disease, since the bird, flying from burrow to burrow, might readily carry infected fleas over long distances. If this be true, the eradication of the disease is greatly complicated.⁵ The intimate association of rats and ground squirrels has been observed repeatedly. In one locality in the outskirts of a city both were taken alive from the same burrows and rat fleas were combed from the hair of the squirrel.⁶

The mode of transfer from squirrel to man is more difficult to understand. Simpson⁷ suggests that cattle on the range are the unrecognized factor which provides for the conveyance of infected fleas from squirrel to man. He states that fleas abound in and about squirrel villages and the cattle as they range over this territory lie down to rest in and among these villages. Since the fleas quickly desert an animal after death, the cattle will more readily acquire fleas in villages containing infected squirrels, and especially if dairy cattle were concerned, the daily contact with men would give abundant opportunity for the transfer of the infected fleas. Some of the squirrel villages known to be plague infected are so isolated as to afford only occasional contact with man, yet cattle were seen grazing near these villages and may furnish the connecting link in transmission.

Of the species of wild rodents known to be infected in nature, the California ground squirrel, *Citellus beechyi*, is unquestionably the most important. It has also been the longest recognized

⁵ Rucker, W. C., "Public Health Reports," Vol. 24, p. 1225.

⁶ "Public Health Reports," Vol. 25, p. 623.

⁷ "Public Health Reports," Vol. 25, p. 250.

as an element in the plague situation. Its habits and distribution have been outlined by Merriam,⁸ who also discusses means for its systematic destruction.

Much less well known is another California rodent which has very recently been shown to be susceptible to bubonic plague under natural conditions. This species is the woodrat, *Neotoma fuscipes annectens* Eliot. It is distinctly a new world form, of which several species occur on the Pacific coast and into the desert region as far as Utah and Colorado. Evidently, if the infection can be transmitted from one to another of these species, the disease will thus extend over a large area. Rucker,⁹ says of their habits:

Wood rats are nocturnal in their habits and are seldom seen in the light of open day except when it is very cloudy. For the most part, they are found along small wooded arroyos, in which they build their nests, often of the most elaborate design. Those which the writer has had the opportunity of dissecting consist of pieces of driftwood arranged in a pile, sometimes 6 or 7 feet in diameter and 3 feet high. There is usually only one entrance to the nest and this is lined with sharp sticks. It is said that where cactus is plentiful the tunnel is lined with cactus spines as a protective measure against other mammals. The interior of the nest is frequently arranged into three stories, and contains storehouses and living rooms. Usually there is an exit which is frequently found near the base of a tree. This is utilized as a means of escape when the ordinary entrance is blocked and some enemy begins to tear the nest apart. The storehouses in several instances contained large quantities of the corms of a plant growing in the immediate neighborhood. Although wheat was growing but a few hundred yards away, none of this was found in these nests. In certain regions the *Neotoma* store up large quantities of mesquite beans, and these caches are raided annually by the Indians, who use them for food. They also store up mushrooms, certain varieties of puffballs and acorns.

In view of the part played by fleas in the transmission of the disease, it is interesting to note the average number of fleas from a squirrel is much larger than from a rat or from any other host yet observed. Much collateral work has been done on the species of fleas, found on the various rodents which suffer from bubonic plague, and on the relations of these fleas to the transfer of the disease as shown by their ability or readiness to bite man and other hosts. The majority of the two rat fleas common in San Francisco, viz., *Laemopsylla cheopis* Roth and *Ceratophyllus*

⁸ "Public Health Reports," Vol. 23, No. 52.

⁹ "Public Health Reports," Vol. 25, No. 1, p. 2.

fasciatus Bosc., will bite man under experimental conditions, while the squirrel fleas, *Hoplopsyllus anomalus* and *Ceratophyllus acutus*, feed readily on man's blood.¹⁰ The same authors have also shown¹¹ that fleas from rodents will adapt themselves to a host of a different species and that fleas from squirrels will attack rats even in the presence of their normal host. Plague bacilli have been demonstrated in both the common squirrel flea, *Ceratophyllus acutus*, and also in the lice (probably *Hæmatopinus montanus*) very commonly found on the same host.¹² Experimental work has also been done to determine the susceptibility to bubonic plague of other rodents in which the disease has not yet been reported under natural conditions.¹³ Finally in experimental cases¹⁴ rat fleas have conveyed plague from rats to ground squirrels and squirrel fleas from squirrel to squirrel, and also to guinea pigs and rats.

H. B. WARD.

DESERT PLANTS¹

In the opinion of the reviewer, this book constitutes the most noteworthy contribution thus far submitted from the Desert Botanical Laboratory. In a measure it may be said to be the outcome of previous contributions and others not hitherto published. Investigations in progress there during the several years since the establishment of the desert laboratory, while they have a wider range of application, have centered in the effort to describe and interpret the interplay of stimulus and response as between desert environment and plants in the desert. It in no way detracts from the merit of Professor Spalding's contribution to say that the results of these investigations constitute a prominent feature of the book, and indeed it stimulates increased appreciation of his work to observe that he assumed the difficult task of so correlating the results of a staff of specialist investigators as to bring about a reasonable measure of interpretation of the rôle of environmental stimuli in shaping the origin, distribution, associations and movements of desert plants. The book lays claim to being only a partial interpretation of the

¹⁰ McCoy and Mitzmain, "Public Health Reports," Vol. 24, No. 8.

¹¹ "Public Health Reports," Vol. 24, p. 1013.

¹² Geo. W. McCoy, "Public Health Reports," Vol. 24, p. 475.

¹³ Geo. W. McCoy, *Jour. Infectious Diseases*, Vol. 6, p. 283.

¹⁴ Public Health Reports, Vol. 25, p. 465 and 659.

¹ "Distribution and Movements of Desert Plants," by Volney M. Spalding, Carnegie Institution of Washington, publication No. 113, October, 1909, pp. 144, with 30 plates.